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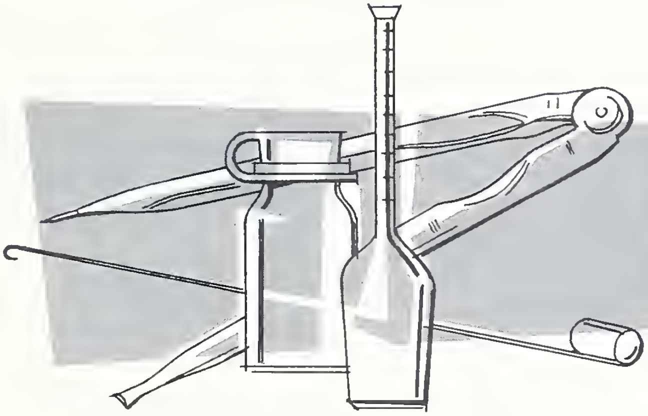
COSTS OF BUTTERFAT SAMPLING AND TESTING PROGRAMS



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Agricultural Marketing Service
Marketing Research Division
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COSTS OF BUTTERFAT SAMPLING AND TESTING PROGRAMS

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SUMMARY AND CONCLUSIONS

The purpose of this study was to estimate the relative costs of limited testing programs for finding the average monthly butterfat content of producer milk shipments. Such information is useful in selecting the most economical sampling and testing routine for a given producer or plant.

A schedule of sampling and testing costs was constructed from time studies of operations at 6 receiving rooms and 4 laboratories. Current equipment and supply costs and other cost data were obtained at 6 laboratories. At 3 small laboratories, unit costs were higher by 11.6 cents per test. Test loads averaged 23 percent of the average test load at 3 large laboratories.

Testing costs per hundredweight of milk decrease as producer shipments increase. At the 3 laboratories averaging 18,000 tests per year, testing costs for producers shipping 3,000 and 18,000 pounds per month were estimated to be 7.7 cents and 1.3 cents per hundredweight, respectively. With 80,000 tests per year, costs per hundredweight were about half these amounts.

The costs of composite sample programs, relative to costs of fresh sample programs, increase with sampling costs. With no sampling cost, 7-, 10-, and 15-day composite programs cost less than 5, 4, and 3 fresh tests, respectively, and more than 4, 3, and 2 fresh tests, respectively. When all of a man's workload was chargeable to sampling, all composite programs cost more than programs of 15 or less fresh tests.

A previous study has indicated that programs of 8 fresh tests and 10-day composite tests may be equivalent from the standpoint of test variability. This study indicates that such a level of test variability would be attained most economically by using composite samples if there is no sampling cost. Both fresh and composite programs would cost about the same if one man receives and samples can shipments. The fresh sampling program would be most economical if one man's duties are confined to sampling.

Fresh tests tend to represent butterfat receipts while composite tests tend to understate them. Therefore, it would be to the economic advantage of all but the smallest producers to absorb the higher costs of frequent fresh tests rather than the lower costs of fewer tests on composite samples.

INTRODUCTION

Testing milk for butterfat content has been an essential part of dairy operations since the adoption of the Babcock test as a basis for paying producers for milk. It has been carried on independently by milk plant operators who do both the sampling and the testing, and jointly by plant operators who take the samples and agencies which then test them. In some instances both sampling and testing are done by independent third parties such as regulatory agencies or commercial laboratories. Reports are then made to the plant operator, and he uses them as a basis for making payments to producers. Frequently, producer associations and regulatory agencies verify the accuracy of dealers' tests by means of an independent series of check tests.

A sampling and testing program is desirable to maintain an acceptable level of accuracy of the butterfat content with reasonable regard for costs. Daily sampling and testing is commonly regarded as the most accurate program, but it is the most expensive. In almost all cases, the high cost of daily sampling and testing has led to the adoption of more limited programs. In these programs tests are made either on randomly-selected fresh milk samples or on samples of each shipment over a period of several days. Samples may be accumulated or composited, and are preserved until the test is made. Payments to a producer are based upon the average butterfat percentages found in fresh or composite samples.

In selecting a sampling program, one must have a knowledge of both the cost and accuracy of the program. Previous research has dealt with the accuracy of various sampling programs, but little information is available concerning their costs. The object of this report is to provide such information. The costs which were considered include: (1) The average costs per sample of securing the sample and testing it; (2) the average sampling and testing costs per hundredweight where producer shipments differ in size; (3) the costs of fresh and composite sample programs; and (4) the relative costs of attaining specified levels of accuracy in tests through the use of fresh or composite programs.

Method of Study

Operations in several laboratories and receiving rooms were timed to provide criteria for estimating labor costs. Current prices of equipment and supplies were obtained from major dairy equipment firms and private contractors. Cost data were obtained from the records of 6 laboratories. These laboratories included 2 commercial laboratories (laboratories which provided testing services on a fee basis), 2 laboratories conducted by producer associations, and 2 laboratories conducted by regulatory agencies. From this information costs were estimated for 2 sizes of laboratories; the smaller laboratories making 18,000 tests annually, the larger one 80,000 tests annually.

In the laboratories from which information was obtained, testing samples of milk delivered by producers was only one activity. Bacteria count determinations were made on the milk and also the finished products of the plants. Samples of the finished products were also tested for butterfat and flavor. Thus, in order to estimate the costs of butterfat testing it was necessary to allocate costs among these activities. Costs were allocated partly on the proportionate number of tests of each type in the most recent year and partly on estimates provided by the plant or laboratory operator.

Costs of sampling and testing may be divided into those which, over a period of a year, do not vary appreciably in relation to the number of tests and those which do vary with the number of tests. The fixed costs include supervisory and clerical salaries, laboratory maintenance, insurance, licenses, taxes, utilities, rent, depreciation, and interest. Data on fixed costs used in this report were obtained from the records of the six laboratories. Depreciation and interest costs were calculated from the bill of materials needed in setting up a new laboratory, priced at current prices (Appendix tables 6 and 7). Estimates of the cost of building and equipping a new laboratory were based on information obtained from contractors and dairy equipment firms in the summer of 1956. Total equipment costs were higher at laboratories testing 80,000 producer samples, than costs at laboratories testing 18,000 samples, but only to the extent that an additional test bottle shaker, centrifuge, interval timer, and tempering bath were needed. Estimated equipment costs were higher by $492 at the larger model laboratory.

Variable costs (those which vary directly with the number of tests) include costs of laboratory labor and supplies. The labor time required for sampling and testing was determined by observations at 6 receiving rooms and 4 laboratories. Labor costs were determined by applying the going wage rate to the average time required per test 1/. The cost of supplies was determined by applying current prices to the quantities of supplies purchased at the laboratories which furnished data.

1/ Several dairy officials in the Baltimore and Washington milk markets suggested $1.75 per hour as a representative wage for sampler-testers. This basic wage rate was increased by 10 percent to take into account payments for such fringe benefits as social security, pension plans and hospitalization. Other factors, such as replacement labor during vacations and illness increase labor costs further. The resulting wage of $1.93 per hour was used in calculating the labor costs of sampler-testers.

In setting up the model laboratories, the following assumptions were made: (1) Sampling and testing functions are performed competently; (2) other activities carried on in the laboratory utilize fully and productively the time which samplers and testers do not spend in sampling and testing milk from producers; (3) samplers and testers are as efficient on the average as those in the laboratories which were surveyed; and (4) delays in the receiving operation amount to 43 percent of the receiving time [2].

In this study, the emphasis is placed on costs of sampling and testing in terms of cost per test rather than costs per hundredweight of milk for two reasons: (1) Costs for specific producers are more accurate when derived from costs per test. Equal numbers of tests usually are made on the deliveries of all producers at a plant, regardless of the volumes of their individual shipments; (2) costs per test can be compared directly with charges made by commercial laboratories. However, costs are also discussed in terms of cost per hundredweight so that comparisons of particular interest to the plant operator may be made.

ANALYSIS OF COSTS

Fixed Costs of Sampling and Testing

The 6 laboratories for which cost data on sampling and testing butterfat content of milk were available were divided into 2 volume groups (table 1). The 3 high-volume laboratories test, on the average, 80,000 producer samples for butterfat and 110,000 samples of all types per year. The 3 low-volume laboratories averaged 18,000 tests of raw milk and close to 50,000 tests of all types in the same period.

The terms "high-volume" and "low-volume" are relative. An annual output of 18,000 producer tests is the equivalent of 5 fresh tests per month on shipments of 300 producers or of a 10-day composite program for 500 producers. The majority of dairy plant laboratories test only a fraction of 18,000 producer samples annually so probably the fixed costs of testing at most plants are higher than those indicated for "low-volume" laboratories.

Average fixed costs for the high-volume laboratories were estimated at 14.2 cents per test, as compared with 25.8 cents per test for the low-volume laboratories. Supervisory and clerical salaries and rent accounted for two-thirds of this difference. Costs were about 40 percent and 330 percent higher, respectively, at the smaller laboratories. Unit costs of all items were lower at the high-volume laboratories than at the low-volume laboratories.

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[2] French, C. E., Wood, G. B., and Manhart, V. C. Labor Utilization in Milk Receiving Rooms of Indiana Milk Plants. Ind. Agr. Expt. Sta. Bul. 576, 1952.

Table 1.--Estimated average annual fixed costs of producer milk tests on butterfat content at 3 large and 3 small laboratories, 1956

Fixed cost item 1/	Average annual cost per laboratory at -- 3 large laboratories (averaging 80,000 producer milk tests annually)		3 small laboratories (averaging 18,000 producer milk tests annually)	
	Total	Per test	Total	Per test
	Dollars	Cents	Dollars	Cents
1. Supervisory and clerical salaries	8,560	10.7	2,700	15.0
2. Laboratory maintenance	323	.4	177	1.0
3. Insurance, licenses, and taxes	401	.5	186	1.0
4. Utilities	569	.7	266	1.5
5. Rent	881	1.1	872	4.8
6. Depreciation	265	.3	220	1.2
7. Interest on investment	400	.5	233	1.3
Total	11,399	14.2	4,654	25.8

1/ Items 1-5 derived from Appendix table 10.

Item 6 derived from Appendix table 6. Optional equipment is not included.

Item 7 calculated as 5 percent of initial investment for a fresh testing program. Initial investment includes cost of equipment (Appendix table 6) and sufficient operating capital to cover 3 months' operation. Annual freight cost was estimated by dividing the weighted average of freight costs by the estimated life of the equipment.

Variable Labor Costs of Sampling

Labor costs per unit for sampling depend upon the sampling arrangement and the number of days for which samples of producers' deliveries are taken. At the 6 receiving rooms where sampling time was observed, this time varied from 14.7 seconds to 26.0 seconds per weigh tank sampled, and averaged 18.9 seconds (Appendix table 8). Because large producers deliver more than 1 weigh tank of milk, the average sampling time per producer was greater than the time for sampling a weigh tank. It varied from 16.5 seconds to 35.0 seconds and averaged 23.4 seconds.

Sampling costs depend on the amount of paid labor required for sampling. Thus, there is no direct cost for taking samples from farm tanks if the samples are taken by haulers or, in receiving milk in cans, by a member of a receiving crew. Usually the weigher secures a sample from the weigh tank when he is not engaged in other receiving duties and when he does not delay the receiving operation (sampling arrangement A, table 2).

If total receiving time is increased by the time required for sampling, each sample drawn raises the cost of the program (sampling arrangement B). The cost of taking samples, based upon a labor cost of $1.93 per hour, was estimated at about 1.3 cents for each sampling. The multiple sampling involved in composite test programs resulted in costs of 8.8, 12.5, and 18.8 cents per composite sample for 7-, 10-, and 15-day composite samples, respectively.

Table 2.--Estimated variable costs per butterfat test of fresh and composite samples of milk under various sampling arrangements

Variable cost item	Fresh sample tests	Composite sample tests		
		7-day	10-day	15-day
	Cents	Cents	Cents	Cents
Sampling arrangement				
A. Weigher or hauler does sampling 1/	0.0	0.0	0.0	0.0
B. One man receives and samples shipments 2/	1.3	8.8	12.5	18.8
C. One man samples only 3/	6.6	46.4	66.3	99.5
Handling and testing 4/	6.1	6.8	6.8	6.8
Supplies 5/	1.5	1.9	1.9	1.9
Totals				
A. Weigher or hauler does sampling 1/	7.6	8.7	8.7	8.7
B. One man receives and samples shipments	8.9	17.5	21.2	27.5
C. One man samples only	14.2	55.1	75.0	108.2

1/ No added labor cost for sampling.
2/ Cost of taking one sample--23.4 seconds (Appendix table 8) × 0.0536 cents ($1.93 per hour) = 1.25 cents (rounded to 1.3 in table).
3/ Cost of taking one sample--86.5 seconds (Appendix table 8) + 43 percent receiving time delay = 123.7 seconds. 123.7 × 0.0536 = 6.63 cents.
4/ Fresh sample--114.2 seconds (Appendix table 9) × 0.0536 = 6.12 cents. Composite samples--126.2 seconds (Appendix table 9) × 0.0536 = 6.76 cents.
5/ Derived from Appendix table 7.

In a receiving room where one man's duties are confined to sampling can shipments, sampling costs must be based upon the total time required to receive the milk, although the sampler may actually be idle much of the time (sampling arrangement C, table 2). Under these circumstances, the cost of fresh sampling was estimated at 6.6 cents per sample; composite samples ranged from 46.4 cents for 7-day samples to $1 for 15-day samples.

Variable Labor Costs of Handling and Testing

Labor requirements for handling and testing vary with the efficiency of personnel and equipment and the type of program. For example, the time required for washing test bottles ranged from 10.5 to 17.3 seconds per bottle (Appendix table 9). Cleaning sample bottles at the 2 laboratories required 22 seconds for a composite sample bottle, and 15 seconds for a fresh sample bottle.

The total time per test for all handling and testing functions was 114.2 seconds for each fresh test and 126.2 seconds for each composite test. The additional time required for composite tests included 2 seconds for adding preservatives, 3 seconds for tempering samples, and 7 seconds for washing composite bottles. With labor costs of $1.93 per hour, labor requirements were 6.1 cents for each fresh test and 6.8 cents for each composite test (table 2).

Total Variable Costs

Supply costs included the costs of acid, bottles, cleaning supplies, preservative pills for composite samples, and other supplies used for sampling and testing. The amount of supplies used for sampling and testing was obtained from the records of 3 laboratories. The average cost of supplies at the laboratories amounted to 1.5 cents for each fresh test and 1.9 cents for each composite test (table 2). The difference of 0.4 cent per test represented the cost of a milk preservative pill.

Average variable costs for testing, including labor and supply costs (table 2), totaled 7.6 cents for each fresh test, and 8.7 cents for each composite test. These determinations are comparable to Preston's estimate of 10 cents per test for a single fresh or composite test 3/. With one-man receiving crews, average variable costs were 8.9 cents per fresh test and ranged from 17.5 to 27.5 cents for composites of varying length. Where one man's duties were confined to sampling, average variable costs of fresh tests were estimated at 14.2 cents. Average costs of composite tests ranged from 55 cents to $1.08.

3/ Preston, H. J. Developing Butterfat Sampling and Testing Programs. Farmer Coop. Serv. Bul. 5, U. S. Dept. Agr. 1954.

Transportation Costs

Laboratories located at a distance from the plant, such as those operated by regulatory agencies or commercial laboratories, have the additional cost of transporting samples from the plant to the laboratory. This involves a mileage cost and an added labor cost for the time the laboratory's employee drives to and from the plant. The cost per test of transporting samples depends upon the distance of the laboratory from the plant and on the number of samples transported. At the laboratories testing 80,000 samples per year, sample transportation costs ranged from 1.7 cents to 10.4 cents and averaged 6.6 cents per sample. At laboratories testing 18,000 tests per year, the range was 4.6 cents to 14.7 cents and the average 11.0 cents per sample.

Total Costs

Cost Per Test

The total cost of sampling and testing a producer's shipments during the delivery period for butterfat was used in comparing the costs of various programs. This cost comprised the fixed cost associated with the testing of one producer's deliveries, plus the total of variable costs associated with all tests on his shipments (table 3).

The usual practice at dairy plants is to sample and test each producer's shipments the same number of times within a delivery period. Under these circumstances, the average cost of each test is the same for each producer, regardless of the size of his average delivery (table 4, columns 1 and 3).

Cost Per Hundredweight

Cost data are more useful to plant operators when discussed on the basis of costs per hundredweight as plant costs are usually expressed in terms of costs per hundredweight or costs per unit of product. On this basis, costs decrease as producer deliveries increase in size. At laboratories testing 18,000 producer samples a year, testing costs were estimated to be 7.7 cents per hundredweight for producers shipping 3,000 pounds per month, compared with 1.3 cents per hundredweight for producers delivering 18,000 pounds per month. Costs per hundredweight were slightly more than half these amounts for shipments of the same size at laboratories testing annually 80,000 producer samples (table 4, columns 2 and 4).

Table 3.--Estimated total monthly cost per producer of fresh and composite milk sample programs at high- and low-volume laboratories, 1956 1/

Type of program and sample	Estimated monthly cost per producer					
	(A) Weigher or hauler does sampling		(B) One man receives and samples can shipments		(C) One man samples can shipments only	
	High-volume laboratory	Low-volume laboratory	High-volume laboratory	Low-volume laboratory	High-volume laboratory	Low-volume laboratory
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
7-day composite..	1.30	2.29	1.68	2.67	3.28	4.27
10-day composite..	1.21	2.20	1.59	2.58	3.20	4.19
15-day composite..	1.12	2.11	1.50	2.49	3.11	4.10
Fresh sample						
1	1.03	2.02	1.04	2.03	1.09	2.08
2	1.10	2.09	1.13	2.12	1.23	2.22
3	1.18	2.17	1.22	2.21	1.38	2.37
4	1.25	2.24	1.31	2.30	1.52	2.51
5	1.33	2.32	1.40	2.39	1.66	2.65
6	1.41	2.40	1.48	2.47	1.80	2.79
7	1.48	2.47	1.57	2.56	1.94	2.93
8	1.56	2.55	1.66	2.65	2.09	3.08
9	1.63	2.62	1.75	2.74	2.23	3.22
10	1.71	2.70	1.84	2.83	2.37	3.36
11	1.79	2.78	1.93	2.92	2.51	3.50
12	1.86	2.85	2.02	3.01	2.65	3.64
13	1.94	2.93	2.11	3.10	2.80	3.79
14	2.01	3.00	2.20	3.19	2.94	3.93
15	2.09	3.08	2.29	3.28	3.08	4.07
16	2.17	3.16	2.38	3.37	3.22	4.21
17	2.24	3.23	2.47	3.46	3.36	4.35
18	2.32	3.31	2.56	3.55	3.51	4.50
19	2.39	3.38	2.65	3.64	3.65	4.64
20	2.47	3.46	2.74	3.73	3.79	4.78
21	2.55	3.54	2.82	3.81	3.93	4.92
22	2.62	3.61	2.91	3.90	4.07	5.06
23	2.70	3.69	3.00	3.99	4.22	5.21
24	2.77	3.76	3.09	4.08	4.36	5.35
25	2.85	3.84	3.18	4.17	4.50	5.49
26	2.93	3.92	3.29	4.26	4.64	5.63
27	3.00	3.99	3.36	4.35	4.78	5.77
28	3.08	4.07	3.45	4.44	4.93	5.92
29	3.15	4.14	3.54	4.53	5.07	6.06
30	3.23	4.22	3.63	4.62	5.21	6.20

1/ 1,000 producer plants testing annually 80,000 samples. Each producer's share of the monthly fixed costs would be $0.95.

Calculation: Annual fixed cost outlay for 80,000 tests = $11,399 (table 1)
Annual fixed cost for each of 1,000 producers = $11.40
Monthly fixed cost for each of 1,000 producers = $0.95

200 producer plant testing annually 18,000 samples. Each producer's share of the monthly fixed cost would be $1.94.

Calculation: Annual fixed cost outlay for 18,000 tests = $4,654 (table 1)
Annual fixed cost for each of 200 producers = $23.27
Monthly fixed cost for each of 200 producers = $1.94

Table 4.--Effect of size of raw milk shipments on the average cost in a program of five fresh tests; yearly test loads of 18,000 and 80,000 tests

Average monthly milk shipment per producer	Average cost 1/			
	18,000 test program		80,000 test program	
	Per test	Per cwt.	Per test	Per cwt.
Hundredweight	Cents	Cents	Cents	Cents
30	46.4	7.7	26.6	4.4
60	46.4	3.9	26.6	2.2
90	46.4	2.6	26.6	1.4
120	46.4	1.9	26.6	1.1
150	46.4	1.5	26.6	0.9
180	46.4	1.3	26.6	0.7

1/ Assuming there is no sampling cost (see figure columns 1 and 2 under A, Table 3).

APPLICATION OF COST ANALYSIS

Fresh vs. Composite Sample Programs

Many testing programs are based upon composite samples, although it is recognized that there is a tendency for such samples to yield lower butterfat percentages than fresh samples. The use of composite tests has been justified on the grounds that their downward bias is inconsequential, and that they approximate the upward bias of the Babcock method over ether extraction methods. In addition, composite tests vary less than fresh tests, and usually involve fewer tests and lower costs than fresh test programs. There is considerable information available for evaluating the relative accuracy of fresh and composite sampling programs 4/, but there has been little published research on the relative costs of such programs.

4/ Erdmann, H. H. A Statistical Analysis of Butterfat Tests of Milk Based on Random Fresh Milk Sampling. Rpt. of Office of Chicago Milk Market Administrator, Chicago, Ill. 1950. Herrmann, L. F., Bryan, W. G., and Anderson, E. D. Sampling Routines and the Accuracy of Patrons' Butterfat Tests. Mktg. Res. Rpt. No. 66, Agr. Mktg. Serv., U. S. Dept. Agr. 1954. Preston, H. J. Butterfat Sampling in Bulk Handling and Comparative Milk Solids Losses. Farmer Coop. Serv. Gen. Rpt. No. 10. U. S. Dept. Agr. 1954. Preston, H. J. Developing Butterfat Sampling and Testing Programs. Farmer Coop. Serv. Bul. 5. U. S. Dept. Agr. 1954.

Unlike fresh test programs, composite programs involve the use of daily samples. Therefore, program costs were compared separately under two assumptions: (1) That sampling required no additional costs; and (2) that sampling required outlays.

Conditions Without Sampling Costs

With no measurable sampling cost, the variable costs of testing amounted to 8.7 cents for a composite test, and 7.6 cents for a fresh test (table 2). Higher costs of composite tests resulted from a .4 cent cost for each preservative pill, and from additional labor costs of .7 cent for adding the preservative to the sample, tempering composite samples preparatory to pipetting samples, and cleaning composite sample glassware 5/.

In comparing various fresh and composite sample programs where there is no cost for taking the sample, a 7-day composite program costs more than 4 but less than 5 fresh tests. Ten-day composites cost more than 3 but less than 4 fresh tests, and 15-day composite programs cost less than 1 or 2 fresh tests (fig. 1).

Conditions With Sampling Costs

If there is a cost connected with taking the sample itself, a greater number of fresh samples can be taken for the cost of any given composite sampling program (fig. 1). If can shipments are received and sampled by one man, 7-, 10-, and 15-day composite programs cost slightly more than 8, 7, and 6 fresh tests, respectively. Where one man's duties are confined to sampling can shipments, all types of composite programs cost more than programs of as many as 15 fresh tests.

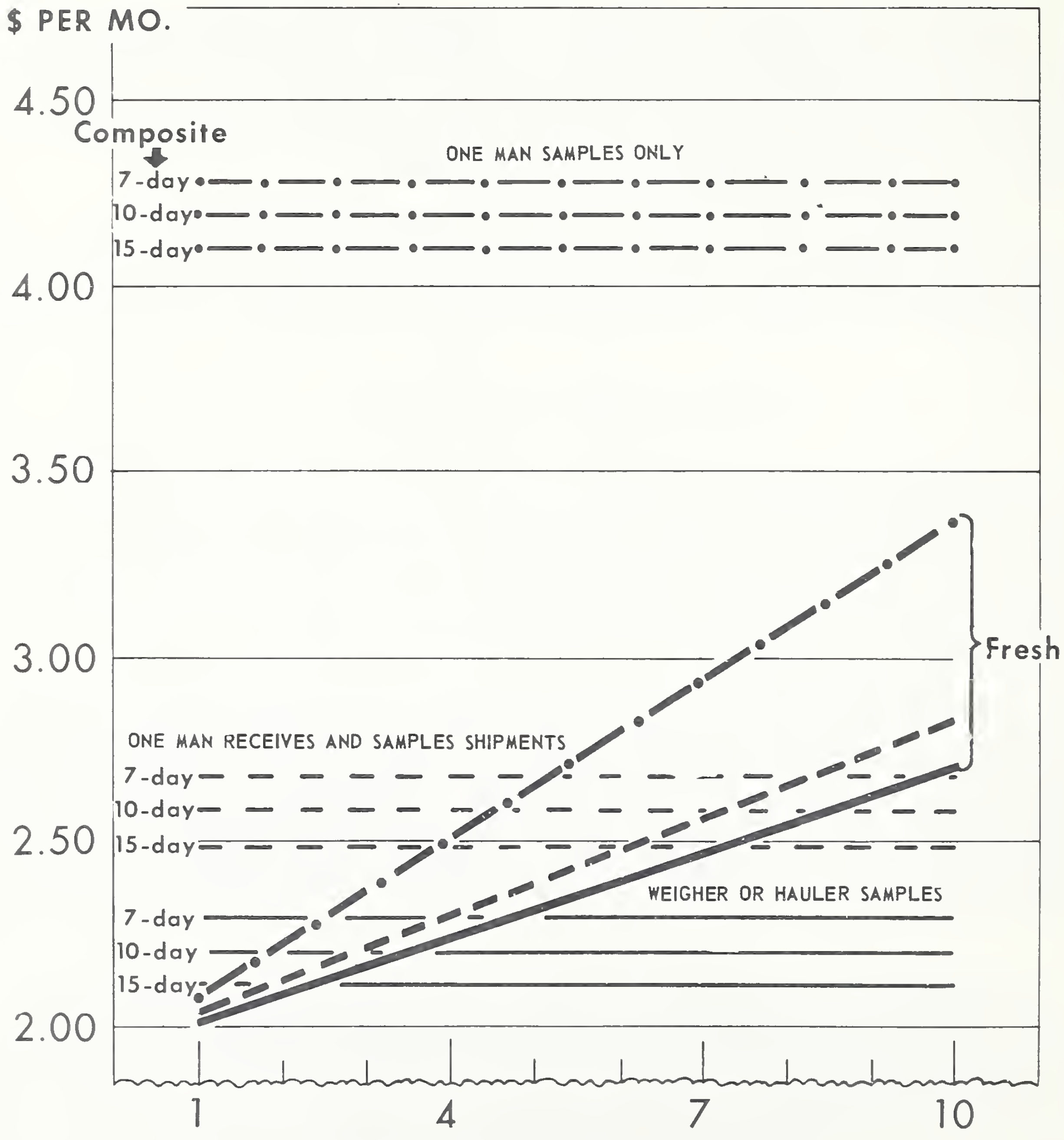
For plants shifting from can to farm tank assembly, the sampling function is transferred from the receiving room to the hauler. This transfer usually eliminates practically all sampling costs. If a plant shifts completely from can to farm tank assembly, composite samples may become economically preferable where costs previously favored fresh sampling. However, if a plant shifts only partially to farm tank assembly, the advisability of using fresh or composite samples may have to be evaluated in terms of the available labor as well as the cost.

5/ The laboratories studied did not temper fresh samples although the Association of Official Agricultural Chemists' Official Methods of Analysis, 8th Edition, calls for fresh samples to be tempered at the same temperature as composite samples.

Comparison of Composite and Fresh Sampling Programs

COST OF BUTTERFAT TESTING

Estimated Total Monthly Cost Per Producer, 1956*



* AT LABORATORIES TESTING 18,000 SAMPLES PER YEAR

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Equivalent Fresh and Composite Programs

Herrmann, Bryan, and Anderson compared fresh and composite test programs from the standpoint of variability and bias 6/. Although their findings apply only to tests on shipments at one plant in one month, they provide some basis for evaluating which type of program is more economical in a given situation. It was found that the averages of fresh tests fluctuate within narrow limits around the true monthly average tests 7/, and that the average of composite sample tests was significantly lower than the true monthly average tests. Comparisons were made between fresh and composite programs by setting up conditions and determining the number of fresh samples that could be expected to equal composite samples under these conditions. Applying the estimated testing costs (table 3) to equivalent fresh and composite programs indicates which type of program is more economical in a given situation.

Variability and Cost

Producers frequently express concern over monthly changes in payment tests. It was found that similar variability in tests would be attained by 10-day composites in comparison with a 12 fresh-test program, and by 15-day composites in comparison with a 10 fresh-test program. Both 10- and 15-day composite programs cost less than the equivalent fresh test program when there is no sampling cost or when only a part of a man's workload is allocated to sampling cost (table 3, sampling arrangements A and B). However, when all of a man's workload is allocated to sampling cost, fresh test programs are more economical (table 3, sampling arrangement C).

Because of the downward bias in tests of composite samples, a somewhat greater variability could be tolerated in fresh than in composite samples. For this reason, Herrmann et al. suggested that 8 fresh samples probably could be considered to be equal or superior to 10-day composites, and that 5 fresh samples would be equivalent to 15-day composites. Costs for such programs indicate that the use of composite samples is economically justifiable when there is no sampling cost. They also indicate that there is little cost advantage in either fresh or composite programs when one man receives and samples can shipments, and that the use of composite samples is uneconomical when one man's duties are confined to sampling.

6/ Herrmann, L. F., Bryan, W. G., and Anderson, E. D. (see footnote 4).

7/ The average of tests on each shipment weighted by the quantity of each shipment.

Accuracy and Cost

Producers are interested primarily in the accuracy of a program. From this standpoint, higher costs could be tolerated in fresh test programs, which tend to represent the true monthly average, than in composite test programs, which tend to underestimate butterfat receipts.

The amount by which costs of fresh test programs could exceed costs of composite test programs, at no disadvantage to the producer, depends upon the value of the unaccounted for butterfat. For example, if composite tests understate butterfat shipments by 0.05 percent, the average monthly payment to a producer shipping 9,000 pounds per month (300 pounds per day) would be $3.60 lower on the average than if the payment were based upon fresh tests (table 5). Therefore, if the average reduction in monthly payment is considered as an added cost to the producer, a 7-day composite program would cost the producer much more than a program of daily fresh tests [8].

Table 5.--Reduction in monthly payments to different-sized producers resulting from downward bias of composites

Percent of butterfat by which composite test is lower than true monthly average	Reduction in monthly payment when producer production in hundredweight per month is--[1]			
	30	90	150	300
	Dollars	Dollars	Dollars	Dollars
0.01	.24	.72	1.20	2.40
.02	.48	1.44	2.40	4.80
.03	.72	2.16	3.60	7.20
.04	.96	2.88	4.80	9.60
.05	1.20	3.60	6.00	12.00
.06	1.44	4.32	7.20	14.40
.07	1.68	5.04	8.40	16.80
.08	1.92	5.76	9.60	19.20
.09	2.16	6.48	10.80	21.60
.10	2.40	7.20	12.00	24.00

[1] Based upon an 8-cent butterfat differential.

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[8] Cost of a 30-day fresh-test program, $4.22 (table 3, column 2). Cost of a 7-day composite program, $2.29 (table 3, column 2), plus payment reduction, $3.60 = $5.89.

In a cooperative plant the lower payment based on composite samples would tend to be offset by the increase in patronage refunds. However, there is reason to believe that not all members would fare alike, because the composite test bias appears to be greater in high-test milk 9/.

These data indicate that it would be to the economic advantage of most producers to absorb the higher costs of frequent fresh tests than the lower costs of periodic composite tests. This is particularly applicable when producer shipments are large or where composite and check tests on fresh samples differ widely.

9/ Preston, H. J. Developing Butterfat Sampling and Testing Programs. Farmer Coop. Serv. Bul. 5. U. S. Dept. Agr. 1954.

APPENDIX

Table 6.--Initial investment and depreciation cost of equipment at laboratory testing annually 18,000 samples 1/

Item 2/	Estimated purchase price	Estimated life 3/	Annual equipment depreciation cost
	Dollars	Years	Dollars
1. Laboratory (construction)	1,750.00	20	88.00
2. Refrigerator	450.00	15	30.00
3. Wall cabinets	100.00	15	7.00
4. Table and 2 chairs	40.00	15	3.00
5. Desk	60.00	15	4.00
6. Miscellaneous fixtures	25.00	5	5.00
7. Acid pump	14.40	10	1.50
8. Acid trunnion with 17.5 ml. bottle	41.60	10	4.00
9. 36-test bottle shaker	153.00	10	16.00
10. 36-bottle thermostatically controlled centrifuge	166.00	19	9.00
11. Interval timer	11.80	3	4.00
12. Electrical tempering bath	161.00	10	16.00
13. 36-test bottle washer	164.00	10	17.00
14. Vacuum sampler 4/	495.00	10	50.00
15. Meniscus reader 4/	41.50	10	4.00
16. 24 composite bottle washer 4/	199.00	10	20.00
Estimated freight charge	15.00	---	15.00
Total	3,887.30		293.50
Less optional items	735.50		74.00
Total	3,151.80		219.50

1/ The estimated initial investment in equipment for 80,000 tests per year would be increased by $492, the cost of an additional test bottle shaker, centrifuge, interval timer, and tempering bath. Estimated annual depreciation costs would be increased by $45.

2/ Items 1-6 were secured from Washington, D. C. firms; items 7-16 were the average of prices quoted by several dairy equipment companies.

3/ From Bulletin "F," Bureau of Internal Revenue, revised to January 1942, and from suggestions of officials of that agency.

4/ Optional equipment.

Table 7.--Initial investment and cost of supplies, laboratory testing annually 18,000 producer samples for butterfat

Supply item	Price per unit 1/	18,000 test operation	
		Initial investment	Annual supply cost 2/
	Dollars	Dollars	Dollars
Acid carboy	15.00/200 lb. carboy	15.00	No cost - returnable
Babcock acid	7.75/200 lbs.	50.38	50.38
8 percent test bottles	9.07/dozen	272.10	54.42
8-oz. sample bottles	3.52/dozen	140.80	21.70
Pipettes	1.06/each	10.60	15.90
Test bottle racks	4.95/rack	29.70	4.95
8-oz. sample bottle trays	2.25/rack	40.50	2.25
Cleaner	23.70/100-lb. keg	71.10	71.10
Test bottle brushes	2.10/dozen	3.15	3.15
8-oz. sample bottle brushes	9.75/dozen	14.63	14.63
Pipette brushes	0.20/each	0.60	0.60
Pocket thermometers	2.28/each	4.56	2.28
Floating thermometers	1.35/each	8.60	5.40
1/2-pt. sampling dipper 3/	6.60/each	13.20	2.20
1-oz. sampling dippers 4/	3.30/each	6.60	3.30
Corrosive sublimate pills 4/	4.25/1000-pill jar	76.50	76.50
Dividers	1.60/pair	4.80	4.80
Freight charge		10.00	10.00
Totals			
Fresh sample program		689.72	263.76
Composite sample program		759.62	341.36

1/ Based upon average of prices quoted by 3 major dairy equipment firms.

2/ Based upon the average of replacement rates reported by 3 of the cooperating laboratories.

3/ Used only in fresh sample programs.

4/ Used only in composite sample programs.

Table 8.--Time required for receiving and sampling can shipments at 6 receiving rooms, 1956

Receiving room	How sample is taken	Average size of shipments (pounds)	Average receiving time per shipper (seconds)	Average sampling time per shipper 1/ (seconds)	Average sampling time per weigh tank (seconds)
A	Mechanically	591	81	16.5	14.7
B	Manually	545	102	17.1	15.0
C	Manually	843	83	18.3	14.9
D	Manually	981	96	25.9	19.5
E	Mechanically	484	43	27.6	26.0
F	Manually	1,163	114	35.0	23.3
Average.		768	86.5	23.4	18.9

1/ Sampling time includes transporting of racks to and from refrigerator, hand agitation of weigh tank contents, and actual securing of sample.

Table 9.--Average time required per test for handling, testing, washing, and miscellaneous functions at 4 laboratories, 1956

Function	Laboratories				Average	
	A	B	C	D		
	Composite sample	Composite sample	Fresh sample	Fresh sample	Composite	Fresh
	Seconds 1/	Seconds 1/	Seconds 1/	Seconds 1/	Seconds 1/	Seconds 1/
Handling:						
Add preservative to composite bottle	2.0	2.0	2/	2/	2.0	2/
Number sample bottles	4.0	4.0	4.0	4.0	4.0	4.0
Transport sample from receiving room, or refrigerator, to laboratory	2.0	2.0	2.0	2.0	2.0	2.0
Prepare tempering bath	3.0	3.0	3/	3/	3.0	3/
Testing:						
Pipette sample	18.7	20.1	18.2	17.9	18.7	18.7
Add acid to final test reading	60.0	44.1	38.0	53.3	48.9	48.9
Washing:						
Wash test bottles	17.3	13.0	10.5	4/	13.6	13.6
Wash sample bottles	4/	22.0	15.0	4/	22.0	15.0
Miscellaneous laboratory chores	12.0	12.0	12.0	12.0	12.0	12.0
Total					126.2	114.2

1/ All time measurements based upon 36 sample Babcock test operations.
2/ Not required in fresh testing.
3/ Not used in fresh testing at laboratories included in study.
4/ Timing not available.

Table 10.--Annual costs chargeable to testing of producer milk samples for butterfat at 6 laboratories, 1956

Cost item	Laboratories					
	Large 1/			Small 2/		
	A	B	C	D	E	F
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1. Supervisory and clerical salaries	8,600	8,833	8,247	4,877	3/	523
2. Laboratory maintenance	328	201	439	255	229	47
3. Insurance, licenses, taxes	720	157	326	380	128	51
4. Utilities	1,080	178	450	479	270	48
5. Rent	1,350	513	780	1,680	756	180
Annual number of producer tests	96,000	75,000	69,000	27,000	19,000	8,000

1/ Averaging 80,000 producer milk tests per year.
2/ Averaging 18,000 producer milk tests per year.
3/ Not available.